METRICS AND MEASUREMENT

Name AE

In the chemistry classroom and lab, the metric system of measurement is used, so it is important to be able to convert from one unit to another.

mega	kilo	hecto	deca	Basic Unit	deci	centi	milli	micro
(M)	(k)	(h)	(da)	gram (g)	(d)	(c)	(m)	(μ)
1,000,000	1000	100	10	liter (L)	.1	.01	.001	.000001
10^6	10^3	10^2	10^1	meter (m)	10^{-1}	10^{-2}	10^{-3}	10^{-6}

Factor Label Method

1. Write the given number and unit.
2. Set up a conversion factor (fraction used to convert one unit to another).
   a. Place the given unit as denominator of conversion factor.
   b. Place desired unit as numerator.
   c. Place a "1" in front of the larger unit.
   d. Determine the number of smaller units needed to make "1" of the larger unit.
3. Cancel units. Solve the problem.

Example 1: 55 mm = _____ m

$$\frac{55\ \text{mm}}{} \times \frac{1\ \text{m}}{1000\ \text{mm}} = 0.055\ \text{m}$$

Example 2: 88 km = _____ m

$$\frac{88\ \text{km}}{} \times \frac{1000\ \text{m}}{1\ \text{km}} = 88{,}000\ \text{m}$$

Example 3: 7000 cm = _____ hm

$$\frac{7000\ \text{cm}}{} \times \frac{1\ \text{m}}{100\ \text{cm}} \times \frac{1\ \text{hm}}{100\ \text{m}} = 0.7\ \text{hm}$$

Example 4: 8 daL = _____ dL

$$\frac{8\ \text{daL}}{} \times \frac{10\ \text{L}}{1\ \text{daL}} \times \frac{10\ \text{dL}}{1\ \text{L}} = 800\ \text{dL}$$

The factor label method can be used to solve virtually any problem including changes in units. It is especially useful in making complex conversions dealing with concentrations and derived units.

Convert the following.

1. 35 mL = __________ dL
2. 950 g = __________ kg
3. 275 mm = __________ cm
4. 1,000 L = __________ kL
5. 1,000 mL = __________ L
6. 4,500 mg = __________ g
7. 25 cm = __________ mm
8. 0.005 kg = __________ dag
9. 0.075 m = __________ cm
10. 15 g = __________ mg

SCIENTIFIC NOTATION

Name ____________________

Scientists very often deal with very small and very large numbers, which can lead to a lot of confusion when counting zeros! We have learned to express these numbers as powers of 10.

Scientific notation takes the form of $M \times 10^n$ where $1 \leq M < 10$ and "n" represents the number of decimal places to be moved. Positive n indicates the standard form is larger than zero whereas negative n would indicate a number smaller than zero.

Example 1: Convert 1,500,000 to scientific notation.
We move the decimal point so that there is only one digit to its left, a total of 6 places.

$1{,}500{,}000 = 1.5 \times 10^6$

Example 2: Convert 0.000025 to scientific notation.
For this, we move the decimal point 5 places to the right.

$0.000025 = 2.5 \times 10^{-5}$

(Note that when a number starts out less than one, the exponent is always negative.)

Convert the following to scientific notation.

1. 0.005 = ____________________
2. 5,050 = ____________________
3. 0.0008 = ____________________
4. 1,000 = ____________________
5. 1,000,000 = ____________________
6. 0.25 = ____________________
7. 0.025 = ____________________
8. 0.0025 = ____________________
9. 500 = ____________________
10. 5,000 = ____________________

Convert the following to standard notation.

1. 1.5×10^3 = ____________________
2. 1.5×10^{-3} = ____________________
3. 3.75×10^{-2} = ____________________
4. 3.75×10^2 = ____________________
5. 2.2×10^5 = ____________________
6. 3.35×10^{-1} = ____________________
7. 1.2×10^{-4} = ____________________
8. 1×10^4 = ____________________
9. 1×10^{-1} = ____________________
10. 4×10^0 = ____________________

PERCENTAGE ERROR

Name ______________

Percentage error is a way for scientists to express how far off a laboratory value is from the commonly accepted value.

The formula is:

$$\% \text{ error} = \left| \frac{\text{Accepted Value} - \text{Experimental Value}}{\text{Accepted Value}} \right| \times 100$$

→ absolute value

Determine the percentage error in the following problems.

1. Experimental Value = 1.24 g
   Accepted Value = 1.30 g

   Answer: ____________

2. Experimental Value = 1.24×10^{-2} g
   Accepted Value = 9.98×10^{-3} g

   Answer: ____________

3. Experimental Value = 252 mL
   Accepted Value = 225 mL

   Answer: ____________

4. Experimental Value = 22.2 L
   Accepted Value = 22.4 L

   Answer: ____________

5. Experimental Value = 125.2 mg
   Accepted Value = 124.8 mg

   Answer: ____________

Name ______________________ Period ________ Date __________

ACCURACY AND PRECISION

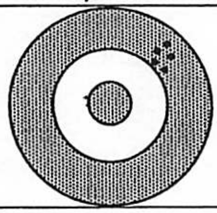
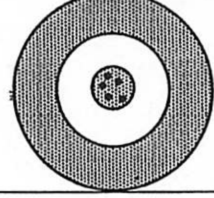
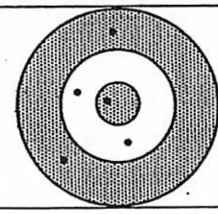
Definitions:

Accuracy – how close a measurement is to ______________________________

Precision – how close a measurement is to ______________________________

Precision versus Accuracy:

Look at each target and decide whether the "hits" are accurate, precise, both accurate and precise, or neither accurate nor precise: (Note: An accurate "hit" is a bulls eye!)

Accurate?: Yes / No Precise?: Yes / No	Accurate?: Yes / No Precise?: Yes / No	Accurate?: Yes / No Precise?: Yes / No

Precision Problems:

A group of students worked in separate teams to measure the length of an object. Here are their data:

Team 1	Team 2	Team 3	Team 4	Team 5	Team 6	Team 7
2.65 cm	2.75 cm	2.80 cm	2.77 cm	2.60 cm	2.65 cm	2.68 cm

- The average length is ________ cm.
  This is the mean or average.

- Subtract the highest value from the lowest value: _________ cm.
  This is the range or spread.

- Divide this number by 2: _______ cm.
  This is the approximate ± range from the average.

- The precision of the measurement can be shown as average ± range.
  The precision of the measurement was ________±______ cm.

A second group of students obtained the following data:

Team 8	Team 9	Team 10	Team 11	Team 12	Team 13	Team 14
2.60 cm	2.70 cm	2.80 cm	2.75 cm	2.65 cm	2.62 cm	2.78 cm

- The average length is ________ cm.
- The precision of the measurement was ________±_____ cm.

In comparing groups, the first or the second, which group was more precise or was the precision the same? Justify your answer.

Expressing Errors in Measurement:

Scientists often express their uncertainty and error in measurement by giving a percent error. The percent error is defined as:

$$\% \text{ error} = \frac{\text{actual value} - \text{measured value}}{\text{actual value}} \times 100$$

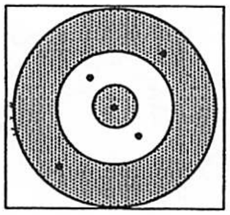
Answer the following four questions. Pay attention to significant figures, and show your work!

1. While doing a lab, a student found the density of a piece of pure aluminum to be 2.85 g/cm^3. The accepted value for the density of aluminum is 2.70 g/cm^3. What was the student's percent error?

2. A student measured the specific heat of water to be 4.29 $J/g \cdot C^{o}$. The literature value of the specific heat of water is 4.18 $J/g \cdot C^{o}$. What was the student's percent error?

3. A student took a calibrated 200.0 gram mass, weighed it on a laboratory balance, and found it read 196.5 g. What was the student's percent error?

4. Accuracy is often expressed as an average of several measurements. Look at the target to the right. In your opinion, how well do the measurements on the target represent: **(Justify your opinion.)**



a. Accuracy?

b. Precision?

Density Problems AE

The density of water is 1.0 g/mL, how much should 100 mL of water weigh?

A bottle of mercury (Hg) has a mass of 176.8 grams and has a volume of 13.0 ml. What is the density of mercury?

How much does 25.0 ml of gasoline weigh if the density of gas is 0.670 g/ml?

Calculate the density of a sample of copper if it has a mass of 13.0 g and 1.46 cm^3?

What would the volume be of a beaker of ethanol be if it had a mass of 500. g. (D of ethanol is 0.806 g/ml)

If you have a block of lead that weighs 3065g and is 3.00 cm high, 15.00 cm long, and 6.00 cm wide, what is it's density?

A cylinder of copper (Cu) has a diameter of 1.00 cm and a height of 6.00 cm. What is the cylinder's mass?